High Speed 3D Hybrid Elastic Seismic Modeling

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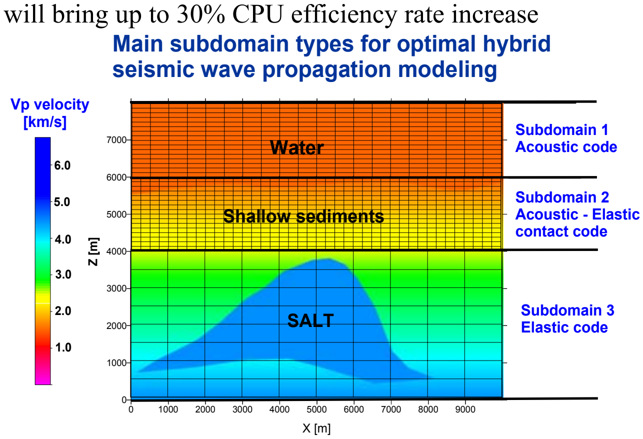
Research Objectives

The best tool for understanding and, imaging complex structure and long offset data is an accurate fully elastic 3D algorithm. The applications of such algorithms are many fold including survey design, hypothesis testing, AVO evaluation, wave field interpretation, generation of test data sets for testing of new migration algorithms and as forward calculation engines in 3D prestack migration algorithms and new full waveform inversion algorithms. While such algorithms have been developed, uniform grid sampling produces costly over sampling of high velocity regions and unnecessarily small time integration steps in low velocity regions. Thus, the scale of the computer resources required to model the entire geologic section, from source locations to the depths of interest, with a fully elastic representation is prohibitive. In addition, the discretization of high contrast boundaries such as the salt-sediment interface can produce high-energy diffraction events in the modeled data, which are often difficult to completely suppress even in processing. There is a critical need for an algorithm which can accurately model and image all of the elastic effects occurring in complex structure while at the same time being efficient enough to be run on clusters of available workstations in a reasonable time.

Approach

We propose to develop an efficient 3D elastic forward modeling algorithm that will address these requirements. There are two critical concepts that will provide for a significant improvement in computation efficiency and accuracy over what is currently available. First is the decomposition of the original three-dimensional model into parts (subdomains) where wave propagation will be computed using the optimal spatial parameterization for each particular subdomain. The second critical concept is the use of local boundary condition matching at high contrast interfaces to eliminate artifacts from grid discretization.

The use of subdomains in finite difference (FD) modeling has several major advantages over current single domain algorithms. First, this approach allows fine girding to be used only in the low velocity regions (sea water, loosely compacted sediments) where it is required and allow courser girding in the higher velocity regions (salt, deep sediments). For a typical undersea salt body structure a use of just 2 subdomains gives factor of 8 in memory and CPU savings which can be used for model size extension. Second, the use of subdomains allows the use of computationally efficient acoustic approach for liquid parts (which gives approximately factor of 5 of speed increase and memory savings) and a complete elastic formulation in the complex portions of the model. Third, just a subset of all subdomains can be used in the first stages to avoid unnecessary computations for the regions which are still out of reach of propagating waves. Considering rather common case of very low velocities in the shallow parts of seismic structures this will bring up to 30% CPU efficiency rate increase



The new variable grid subdomain FD algorithm will be designed for parallel cluster computing using a message passing interface technique. This will make its usage possible for local network computer clusters, and therefore affordable, relatively inexpensive and easily upgradable

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